OPTIONAL FORM NO. 10
5010-104

SECRET

UNITED STATES GOVERNMENT

DD/ST# 4750-65

Memorandum

TO : Chief, General Sciences Division/SI

DATE: 7 October 1965

On file DOC release instructions apply.

FROM : Chief, Astro-Geophysics Branch, GSD/SI

On file NSC release instructions apply.

Misc-5

SUBJECT: Weather Modification

1. For your information some attachments are provided which show the extent of interest and trends in weather modification research in the United States. For example, Federal support for 1967 will be four times that for 1963 and over twice as large as that in 1965. The copy of the letter from President Johnson to the Secretary of Commerce shows that an expanding program has White House backing.

2. At the recent Interagency Conference on Weather Modification sponsored by the National Science Foundation, it was indicated that the level of Federal support for weather modification research may be increased several orders of magnitude over the presently projected 1967 level.

3. AGB has in the past furnished intelligence support to various high level committees. Currently we enjoy good working relations with the National Science Foundation which plays a leading role in coordinating the programs. At the recent Interagency Conference on Weather Modification, Dr. Earl G. Droessler, Chairman of the Conference and Head of the Atmospheric Sciences Section of NSF, privately congratulated [redacted] on his latest SIR on Soviet weather modification and indicated that it had been very helpful. 25X1

4. As the U.S. weather modification program expands, we are likely to have increasing demands for intelligence on Soviet accomplishments. The Soviets are also enlarging their program, and the problem of determining their progress is extremely difficult. Our present staffing allows us to utilize about one-half the time of one analyst on meteorology. I am not particularly trying to make a case for additional help, but I believe that you should be aware of our limitations for future coverage of this field.

[redacted] 25X1

Attachments:
Information which show the extent of interest & trends in Weather Modification research in the U.S.

Distribution:
Orig & 2 - Adsd
3 - AGB

25X1

SECRET

OSI/GSD/AGB [redacted] (7 Oct 65)

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Chief, General Sciences Division/SI 7 October 1965

Chief, Astro-Geophysics Branch, GSD/SI

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Orig & 2 - Fwd
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25X1

SECRET

OSI/OSD/AGB [redacted] (7 Oct 65)

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
INTERDEPARTMENTAL COMMITTEE FOR ATMOSPHERIC SCIENCES
U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

Federal Support for Weather Modification (Millions $)

Fiscal Year:	1959	1960	1961	1962	1963	1964	1965	1966	1967
Weather Modification									
Agriculture	.08	-	.06	.12	.13	.12	.12	.12	.12
ESSA(Wea.Bu.)	.12	-	.06	.22	.19	.18	.30	.50	1.00
Defense	(1.44)	(1.34)	(.75)	(2.75)	(.97)	(1.41)	(1.19)	(1.08)	
Army	.03	-	.16	.38	.44	.73	.02	.07	?
Navy	.41	.35	.23	.37	.35	.50	.86	.75	.84
Air Force	1.00	.99	.36	.40	.18	.18	.31	.26	.32
ARPA	-	-	-	1.60	-	-	-	-	-
Federal Aviation Agency	-	-	-	.04	-	-	-	-	-
Interior	--	--	--	.10	.10	.18	1.10	2.23	3.20
Nation Aeronautics & Space Agency	-	-	-	-	.05	.07	-	-	-
Nation Science Foundation	1.14	1.17	1.54	1.34	1.32	1.57	2.01	2.40	5.49
	2.78	2.51	2.41	4.57	2.76	3.53	4.72	6.13	10.97

THE WHITE HOUSE

Washington

September 14, 1965

COPY

Dear Jack:

I thought your report to the Cabinet Monday on weather was exceptional. This is a field in which I want us to move ahead to make a breakthrough I am convinced is possible for us.

Please express my appreciation to Secretary Hollomon and Dr. White for their contribution to the Cabinet and presentation to the press. I understand that both did fine jobs.

If you think it appropriate, I would like to have your suggestions for a letter of commendation to Mr. Dunn and his staff in Miami on the job they did during the recent hurricane.

Sincerely,

/s/ Lyndon B. Johnson

Honorable John T. Connor
Secretary of Commerce
Washington, D. C.

THE SECRETARY OF COMMERCE
WASHINGTON 25, D.C.

September 13, 1965

MEMORANDUM FOR THE PRESIDENT

SUBJECT: The Weather Services of the
Environmental Science Services Administration

This is a report on the weather services provided by the Environmental Science Services Administration of the Department of Commerce during Hurricane Betsy. This report will also inform you of the work now being done and in prospect to improve our warning services for all the hazards of the physical environment and to broaden our scientific and technological capability to predict, and possibly to modify, the weather.

HURRICANE BETSY

The Weather Bureau provided excellent and timely warnings of Hurricane Betsy. These warnings permitted the evacuation of people and the taking of the necessary precautions to protect life and property. The failure of power and communications systems in New Orleans point up the need for fail-safe facilities to ensure that hazard warnings and information reach the public.

Hurricane Betsy was one of the most intense and destructive storms ever to strike the United States. There has been serious loss of life, and the destruction and damage of property in Southern Florida and in Louisiana and Mississippi will run into the hundreds of millions of dollars. And as you witnessed on Friday, Hurricane Betsy rendered a major American city -- the City of New Orleans -- completely prostrate. The storm knocked out the city's power system, its communications system, and its water purification system, leaving hundreds of thousands of people helpless and bringing the city's economic life to a dead halt.

The toll of Hurricane Betsy would have been far worse but for the magnificent work of the Weather Bureau, which is now an arm of the Environmental Science Services Administration. Hurricane Betsy was first detected at 2 PM EST on August 27, 11 days before it struck the United States mainland. The Weather Bureau tracked Betsy continuously thereafter -- by radar, by satellite, by its own aircraft, and by aircraft of the Navy and the Air Force - and kept Betsy's speed, its stalls, its loops and reversals of course, and its intensity under steady observation.

Although Hurricane Betsy was the most erratic hurricane ever tracked, the Bureau was able to give early and accurate warnings to Southern Florida and to Louisiana and Mississippi. At 5 AM EST on September 6, a hurricane watch was posted for Southern Florida, and at 11 AM a full warning was given. The storm did not strike until early in the morning of September 8 - more than a day and a half later. At 8 PM EST on September 8, a hurricane watch was posted for the Louisiana and Mississippi coasts, and at the same time the evacuation of offshore oil drilling installations was recommended. At 6 AM EST on September 9, a full hurricane warning was hoisted. Betsy struck New Orleans about 10 PM EST that night -- 16 hours later. When Betsy knocked out the power and communications systems of New Orleans, around midnight, the New Orleans hurricane forecast center could no longer function. Under emergency procedures of the Weather Bureau, the Miami center took over the responsibility for issuing hurricane warnings. As a result, all threatened areas were able to receive continuous hurricane bulletins and advisories as long as their communications systems remained intact. The power and communications failures in New Orleans point up the need to ensure that we have fail-safe backup facilities to provide the public with hazard warnings and information.

The early warnings of the Weather Bureau enabled the necessary precautions to be taken. A large measure of credit is also due the mass media -- local newspapers and local radio and television stations. They played a vital role in the dissemination of the Bureau's hurricane warnings. On the basis of the warnings, public officials began to plan for the public safety. Hundreds of thousands were evacuated from low coastal areas. The American Red Cross began to arrange for food kitchens and for clothing and blankets to be moved into hurricane target areas. Ocean vessels moved out of Betsy's path. The National Aeronautics and Space Administration ordered Gemini 5 to land an orbit earlier than had been scheduled. Work installations throughout the threatened areas were shut down, and whatever precautions could be taken to protect factories, work sites, stores, and other places of business were taken. And each individual had time to look to the safety of himself and his family and to the protection of his personal property.

On September 8, The Miami News summed up in an editorial the views of the people of Southern Florida on the value of the hurricane warning service of the Weather Bureau. "Thanks to blessedly long warnings, we were as ready for a hurricane as humans can be." The editorial went on to offer special praise to the personnel of the Weather Bureau.

I join in that praise. While the fine work of the Weather Bureau is the work of hundreds of people, and not of any one man or of any one group, I would like to single out for special praise Mr. Gordon Dunn, the Director of the National Hurricane Center in Miami, and the personnel of the Miami and New Orleans hurricane forecast centers. Mr. Dunn bears the heavy responsibility of ensuring the successful operation of the Nation's hurricane warning system.

AN ENVIRONMENTAL HAZARDS WARNING SYSTEM

An environmental hazards warning plan is being prepared by the Department of Commerce in concert with other Federal agencies. When the plan is implemented, the Nation will have a comprehensive natural hazards warning system.

Hurricane Betsy is only the latest of Nature's furies to strike the United States. Over the past two years our Nation has been struck by a series of natural disasters. In the spring of 1964 the Alaska earthquake and the tidal wave that followed it killed 156 people and caused damages in excess of $400 million. The hurricane season in the late summer and fall of 1964 was the worst in about 25 years. It caused 49 deaths and property damage of more than $500 million. During the past winter floods ravaged California, Oregon, and Washington, claiming 45 lives and property damage of about $500 million. The Palm Sunday tornadoes that ripped through the Midwest earlier this year killed 272 people, injured hundreds more, and caused property damage in excess of $250 million. The current drought in the Northeast is the most severe on record for that region of the Nation, and its end is not in sight. We cannot yet estimate its final cost, but clearly it will be high.

This series of natural disasters has brought home forcefully to all of us the need to develop an adequate warning system for all the hazards of man's physical environment. A special group was formed this past summer -- called the Natural Disaster Warning Survey Group -- to study this problem. The Survey Group comprises representatives of the Environmental Science Services Administration, the Office of Civil Defense, the Office of Emergency Planning, the Federal Communications Commission,

the Army Corps of Engineers, and the Coast Guard. It has consulted with the Geological Survey of the Department of the Interior and with the Forest Service of the Department of Agriculture.

The Survey Group will soon submit its final report containing a plan for a comprehensive environmental hazards warning system. The report will recommend how we can - immediately and with the technology at hand - provide a much improved environmental hazards warning system. It will recommend ways to establish adequate communications for hazard warnings, and it will recommend fail-safe procedures for the dissemination of warnings to the public. It will also include recommendations on the necessary facilities for the observation and detection of weather and other environmental hazards. The implementation of the plan contained in the report will require an increased investment by the Federal Government. When the plan is implemented, the Environmental Science Services Administration will be able to provide the Nation with a comprehensive environmental hazards warning system.

WEATHER MODIFICATION

A vigorous national program to explore the possibilities of weather modification should now be mounted. I intend to have the Environmental Science Services Administration take a leading role in this program.

It is clear that we must now press forward to improve our ability to detect, track, and predict severe weather hazards. It is equally clear that the time has come for us to move vigorously forward to explore the possibilities of modifying and controlling the weather in beneficial ways.

I cannot emphasize too strongly the importance of weather modification to the Nation at large. If we in the United States were to acquire the ability to modify the weather in a substantial way -- to augment precipitation, to blunt the thrust of hurricanes and other severe storms, to suppress hail in crop areas, to cope with lightning discharges in forest areas, and to dissipate all types of fog -- we would have an achievement of vast significance. We would be able to expand our national economy and to improve the well-being of the American people in ways and to a degree that are now inconceivable. The ultimate benefits that weather modification can bring are almost unimaginable.

There is a growing conviction among scientists that a systematic, scientifically sound, properly conceived program of research and development in weather modification is warranted. There are two reasons for this conviction. First, there have been some successful experiments in the field of weather modification, although their results are far from definitive. Second, there have been a number of technological advances over the past decade that give us a new capability for research. We are beginning to simulate atmospheric phenomena on high-speed electronic computers, which enables us to "experiment" with the atmosphere under "controlled" conditions. We are acquiring a deeper understanding of the physical and chemical processes of the atmosphere. We have a new capability for observing the atmosphere. And we have systems for the delivery of man-made materials into the atmosphere that were unavailable to us a few years ago. These advances now make it possible to mount a broad program of research to determine once and for all what types of weather modification are feasible. It will undoubtedly take many years to achieve significant results, but we are now in a position to begin.

A national program of weather modification research will require additional resources to provide the necessary facilities for the conduct of large-scale field research experiments. We must attract to the program the best scientific and engineering talent, both to seek the basic knowledge that we need and to ensure that our field experiments are designed, operated, and controlled in accordance with the best principles of scientific research. And the program must give careful study not only to the scientific problems of weather modification, but also to its social, economic, and legal consequences.

The Environmental Science Services Administration has been giving considerable thought to the future direction of weather modification research in the United States. On July 10, 1965, a special report on weather modification was submitted to the Chief of the Weather Bureau. This report deals with the scientific, social, economic, legal, and legislative aspects of the subject, and it represents an important contribution to the extensive national discussion on weather modification that is now being carried on. Other important reports on the subject are in preparation - one by a special panel of the National Academy of Sciences and another by a special commission of the National Science Foundation. These studies will all help shape Federal policy in the area of weather modification and will help create an important new Federal research program. I intend to have the Environmental Science Services Administration take a leading role in this program.

THE WORLD WEATHER WATCH

If there is to be a significant increase in the ability of our national weather services to issue timely and accurate forecasts of weather hazards, such as Hurricane Betsy, to make long-range weather predictions, and to explore the possibility of large-scale climate modification, we must develop the ability to obtain comprehensive weather data for the entire globe and must conduct a broad program of research on global weather processes. The World Weather Watch is an international undertaking designed to accomplish these objectives. The United States has assumed a prominent role in the development of the Watch, and the Department of Commerce, in concert with other Federal departments and agencies, is now preparing detailed plans for United States participation.

The Formation and Planning of the World Weather Watch

The movement of the atmosphere knows no national boundaries, and what happens in the atmosphere over one nation affects the atmosphere of other nations. Moreover, no one nation can observe and analyze the atmosphere everywhere in the world, and each nation needs the weather data of other nations to provide proper weather services to its people and to the various segments of its economy. And so the nations of the world cooperate closely in weather matters.

The development of the meteorological satellite by the United States opened up radically new opportunities for the acquisition of weather data on a global scale and for international weather cooperation. In 1961, the United States took the initiative within the United Nations to press for a world weather system to exploit these opportunities. The World Meteorological Organization responded with the concept of a World Weather Watch. It is a cooperative effort designed to use modern technology to build an international system for the complete surveillance of the globe's atmosphere and for the rapid dissemination of worldwide weather data.

In June, 1964, in your commencement address at Holy Cross College, you repledged the cooperation of the United States in the development of a World Weather Watch. In October, you requested my predecessor, Secretary Hodges, to bring the Federal departments and agencies that are concerned with international meteorological programs into closer consultation and coordination. An interagency committee was formed in response to this request. On January 1 of this year, a World Meteorological Center was established in Washington - one of three such centers (the others are in Moscow and Melbourne) designated for the World Weather Watch.

The Federal departments and agencies concerned with international meteorological programs are now formulating detailed plans for United States participation in the World Weather Watch. They are formulating plans to further research on the general circulation of the globe's atmosphere and to further research on the interactions between the oceans and the atmosphere (which play, as Hurricane Betsy has reminded us, a prominent role in the formation of the weather). They are also formulating a program of technical assistance to the national meteorological services of the emerging nations and a program to promote international scientific education and training in meteorology. And they are studying how existing international organizations may be strengthened-and whether new international arrangements are necessary - to carry out international programs in meteorology.

The Meteorological Satellite

The meteorological satellite lies at the heart of the World Weather Watch and makes it possible. The satellite gives us for the first time the potential ability to observe and collect data about the atmosphere of the entire globe every day.

At the present time we obtain adequate weather observations for less than 20% of the globe's surface. The rest of the globe, most of it the oceans, has remained inaccessible except for some scattered observation stations. The development of the meteorological satellite has now given us a new and revolutionary tool to overcome this obstacle. This development is of such basic and far-reaching importance that the Environmental Science Services Administration and the National Aeronautical and Space Administration are now exerting every effort to exploit our space technology to perfect this platform.

Since the inception of the meteorological satellite program, eleven meteorological satellites have been placed in orbit -- ten in the Tiros series and one Nimbus satellite. While the data they have provided have been experimental and limited, these satellites have proved to be of immediate practical value. They have provided great assistance in the detection and tracking of severe storms, such as Hurricane Betsy, and in some instances have permitted us to follow their early development where we might otherwise be unaware of their existence. They have provided valuable information -- although only intermittently -- for the oceans and the uninhabited areas of the world.

As valuable as these meteorological satellites have been, we have yet to experience the kinds of benefits that a fully operational meteorological satellite system can provide. This is the next step, and we now expect to have an operational system functioning early next year.

The new system is called the Tiros Operational Satellite System, or, more commonly, the TOS System. It will use a modified Tiros satellite similar to Tiros IX, which has proven itself technologically and which has a sufficiently long life so that we can maintain the system at a reasonable cost.

The establishment of the TOS System will be a huge stride forward. For the first time we will be able to observe the clouds everywhere in the earth's atmosphere each day on a routine basis. This capability will make it possible for us to predict the weather with greater accuracy. It will assist us in giving adequate warning of weather hazards to all who need warning. It will assist us in the forecasts we provide to improve the ability of our agriculture, our transportation, and our industry to plan ahead -- and thereby to become more efficient and more productive. The implications of the TOS System for the safety and well-being of the American people and for the expansion of our national economy are very substantial.

The development of the TOS System is only a beginning, however, The Environmental Science Services Administration and the National Aeronautical and Space Administration have already begun to delve into new areas of research and development. They are seeking to broaden the meteorological satellite system as a comprehensive data-collecting system to provide information about the temperature, the pressure, and the wind structure of the atmosphere as well as the cloud data we now obtain.

The two agencies are also beginning to study the use of synchronous satellites for weather observations. The advantage of the synchronous satellite is that it focuses at all times on the same portion of the globe's surface, and a system of these satellites can provide us with continuous coverage of the ever-changing weather of our planet. A continuous view of the formation, motion, evolution, and dissipation of storms will be of tremendous assistance in the detection and tracking of severe storms, such as hurricanes, so that we may give early warning when required.

New Scientific and Technological Opportunities

The World Weather Watch presents the Nation with a number of new scientific and technological opportunities.

As a result of the development of our satellite-observing and data-communicating techniques, we have a new and expanding capability to obtain meteorological data on a global scale and to communicate these data at high speeds and efficiently. As we develop unconventional sensing systems such as free-floating balloons and ocean buoys, this capability will expand still further. The lack of global data is today one of the greatest obstacles to the improvement of our weather forecasting capability,

and it is clear that the new global data can be put to immediate and effective use in weather forecasting.

If we look further into the future, scientists feel that it may be possible to provide daily weather predictions for a period of up to two weeks ahead. This capability will require that we develop far more complex mathematical procedures than we now have to simulate the behavior of the atmosphere. The successful use of these procedures will in turn depend critically on the continuing flow of adequate data about the global atmosphere and the development of faster and more complex electronic computers. The scientific community is confident that these same data and these same advanced mathematical procedures will facilitate the exploration of the possibilities of large-scale weather modification.

The realization of these new capabilities would represent one of the most significant achievements of modern science and technology, with political and economic implications of vast magnitude. It is clear that our present efforts to achieve these capabilities should be supported with sufficient resources to ensure their success.

The Meaning of the World Weather Watch

The development of the World Weather Watch is important work - for the United States and for the world at large. It will permit us to broaden our scientific knowledge of the globe's atmosphere. It will permit us to provide earlier and better warnings of severe storms and other calamaties of nature. It will further the safety and efficiency of air and sea travel in all parts of the globe. It will further industry, commerce, and agriculture within the borders of each nation cooperating in the Watch. It will permit better land and water management.

These benefits will flow not only to the United States and to those nations that are technologically advanced, but to the less developed nations as well. In the World Weather Watch we have an understanding example of the profound contribution that science and technology can make to the peaceful pursuits of man. The Watch may also serve as a more general lesson for the nations of the world -- and lead to cooperation among them in other fields that require common endeavor.

John T. Connor

ORGANIZED GROUPS WITHIN OR SUPPORTED BY THE FEDERAL GOVERNMENT DEALING WITH THE PROBLEMS OF WEATHER MODIFICATION

1. Special Commission on Weather Modification, National Science Board - Adrian R. Chamberlain

2. Panel on Weather & Climate Modification, National Academy of Sciences/Committee on Atmospheric Sciences - Gordon MacDonald

3. Select Panel on Weather Modification, Interdepartmental Committee on Atmospheric Sciences - Earl G. Droessler

4. Advisory Panel on Weather Modification, National Science Foundation - D. F. Peterson

5. Advisory Panel for Project STORMFURY, Weather Bureau/Navy - Noel LeSeur

6. Advisory Committee on Atmospheric Water Resources, Bureau of Reclamation - B. P. Bellport

EGD 9/22/65

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
INTERDEPARTMENTAL COMMITTEE FOR ATMOSPHERIC SCIENCES
U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

May 25, 1965 COPY

MEMORANDUM FOR DR. DONALD F. HORNIG

SUBJECT: Weather Modification

As you know the availability of the recommendations of the Special Commission on Weather Modification is several months away. In the meantime ICAS has developed, through the mechanism of its Select Panel on Weather Modification, recommendations for action to be taken in certain directions now in order to take optimum advantage of existing knowledge and opportunities.

BACKGROUND

If weather modification, either by alteration of clouds or by perturbation of the radiation balance, is to be achieved in the future, efforts in this field must be of a different kind and on a totally different scale from those of the past. As examples of those areas in which integrated large-scale studies will be required, the following are listed: the structure and dynamics of convective clouds, the physics of precipitation, the initiation of convection in the boundary layer, the effects of cirrus and dust layers on the radiation balance, strato-cumulus and fog dispersal, the dynamics of severe storms, such as thunder- and hailstorms, tornadoes, and hurricanes, and the role of convection therein. Among the many possibilities for new weather modification activity, certain areas of special opportunity exist. These have been selected out by ICAS and are discussed in the following paragraphs.

A study of the structure and dynamics in the convective hail clouds requires extensive field observations, laboratory model studies, and theoretical and numerical investigations. In a field observation program, the general need is for accurate measurements of the profiles of clouds, including: temperatures, humidity, liquid-water content, distribution of hail and other hydrometeors, size of hydrometeors, the vertical and horizontal motions in or near the cloud, radar studies with three and ten centimeters PPI radar, and height-finding RHI radar. In addition, ground-based observation of the electric field and of the pressure-field variations would be required. Such studies, if carried out as part of a hail suppression research project, would permit the investigation of the dynamics and structure of single convective clouds. Beyond lie the untouched problems posed by the relation of an individual cloud to others of the same and of different kinds.

Modification of super-cooled fog is perhaps the best understood of the cloud-modification processes. In certain areas, particularly in the northwest part of the United States, airports are plagued with the formation of super-cooled fog. The weather condition is usually characterized by a high-pressure system and stagnant air circulation. Cooling due to radiation of the earth's surface favors the formation of super-cooled fog in the temperature regime of about -5° to -15°C. While the layer of super-cooled fog has a thickness less than 1,000 feet, it nevertheless effectively prevents the landing and takeoff of aircraft. Even partial dissipation of these fogs or partial restoration of visibility will permit an airport to resume operation. Whether or not the technique of super-cooled fog clearing can be put to routine commercial use to improve the regularity of passenger service seems to rest on an analysis in which the cost of equipment development and operation has to be balanced against the frequency of super-cooled fogs.

POLICY CONSIDERATIONS AND RECOMMENDATIONS

1. Hail Suppression Research. A comprehensive hail suppression research project enjoys high priority in research planning and can be justified now. Such a project would bring together under competent management a broad base of scientific and engineering capability to carry out a long-term experimental program on the modification of hail-producing clouds. An extensive observation and analysis effort is envisaged to document the life cycle of the hail cloud cells. We have the expert groups in the government laboratories, in industry, in the universities, and related organizations whose talents could be organized to undertake this important task.

In hail clouds the freezing mechanism obviously is operative. This provides a physical basis for an experimental program and leads to strong hopes that artificial seeding with freezing nuclei can be effective in suppressing the growth of damaging hail storms. There is evidence that USSR hail suppression experiments appear to be successful, despite the lack of statistical verification of the experiments, according to some of the eminent American meteorologists who recently visited the USSR.

> Recommendation No. 1. The NSF in consultation with other interested government agencies should develop a plan for hail suppression research. Included should be: (a) the scientific and technical details of the program, (b) arrangements for a coordinated effort of available research groups, (c) selection of a suitable experimental site, and (d) assessment of manpower and financial resources needed.

2. Fog Dispersal. Extensive fog dispersal research and development projects are now justified. There is an especially good chance of success with fog dispersal. In the past, the necessary resources have not been committed to explore these opportunities. The socio-economic benefits of fog dispersal are large. The evaluation possibilities are excellent. We have the expert groups in government laboratories, in industry, in the universities, and related organizations capable of undertaking major fog dispersal research and development programs.

There are three fog dispersal problem areas: (a) cold fog, the fog particles are subcooled, (b) warm fog, the fog particles are found above the freezing temperature, and (c) ice fog, the fog particles are all ice crystals. For the present, the Committee has not considered the problem of ice fog; however, (a) and (b) will be discussed separately below.

(a) Cold fog dispersal. Research findings and recent limited operational experience justify the planning and execution of a major engineering effort to fully develop an operational system of cold fog dispersal. The Department of Defense has pioneered most of the research and development on cold fog. In a small pilot project, United Airlines has demonstrated the feasibility of airport clearing in Salt Lake City, even though the procedure is not operational. Being directly related to air transport and safety, the problem lies closest to the operating mission of the Federal Aviation Agency (FAA).

> Recommendation No. 2. The FAA in consultation with other interested agencies should develop a technical plan and requirements for cold fog dispersal which would include an assessment of (1) operational feasibility and evaluation, (2) necessity for supporting research and development, and (3) the federal government role in cold fog dispersal activities.

(b) Warm fog dispersal. A good deal of systematic and intensive research must be planned and carried through. Theoretical and experimental models of warm fog should be studied and developed. Among the techniques to be explored are the coalescence of fog droplets by electric charge, and warm fog seeding with condensation nuclei.

> Recommendation No. 3. The NSF in consultation with other interested government agencies should develop a plan for warm fog dispersal research. Elements of the plan would be similar to those noted in Recommendation No. 1 above.

3. Information. Outside of research activities, the greatest need at the present time is to gather together comprehensive information on all cloud-seeding and other weather modification activity, including prior notification of the intention to conduct such activity. Current

Federal legislation on weather modification (PL 85-510) does not specifically authorize the Government to obtain prior information on cloud-seeding activities. A major expansion of federally supported field projects is under way, some of which will operate over a period of 10 years or more. Such allocations of public funds must be adequately protected. A first step is the systematic collection of information needed to protect the validity of field experiments.

ICAS has agreed that appropriate steps should be taken to request prior notification to the Federal government of intention to conduct weather modification activities. Complete reporting of cloud-seeding activities should be required. The National Science Foundation is preparing a plan to accomplish these objectives and will present the plan to ICAS when completed. In addition to providing a much needed service, such information would be invaluable in advancing research, development, and operations in weather modification, and ensuring that government and other research efforts are better protected from contamination than they are today.

J. Herbert Hollomon
Chairman